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GB A 2076960
GB A 2009417
GB 1561667
GB 1550073
GB 0883438

(58) Field of search
G1A
G1N

(54) Improvements in or relating to a method of control of liquid stock

(57) A method of control of liquid stock in a tank (16) comprises calculating a theoretical stock level generated from the measurement of quantities of stock dispensed to and from the tank (16), measuring of a true stock level at one or more points 114, 115, 116 in the tank, and comparison of these theoretical and true stock levels to give an indication of stock deviation.

The analysis of stock deviation will give a clear indication of loss trends which then may be eliminated.

The tank may hold petrol which is delivered from a tanker 132 in known amount & dispensed via petrol pumps. The true level signals are obtained from level sensors comprising prisms 112 connected by light guides 118, 119 to sources 120 and detectors 121. The calculated level is recorded at each true level.

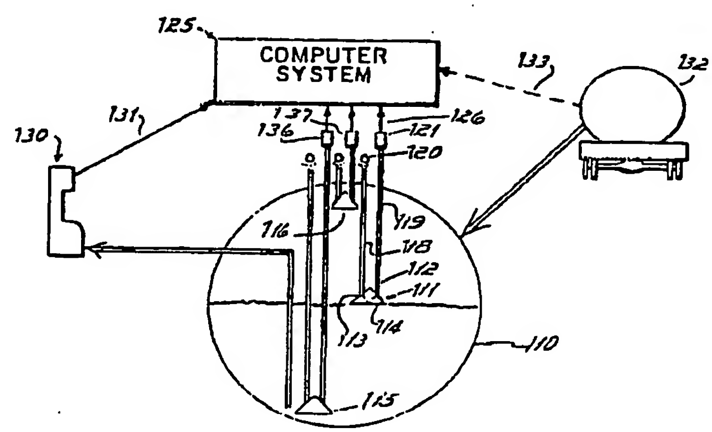

Fig.4.

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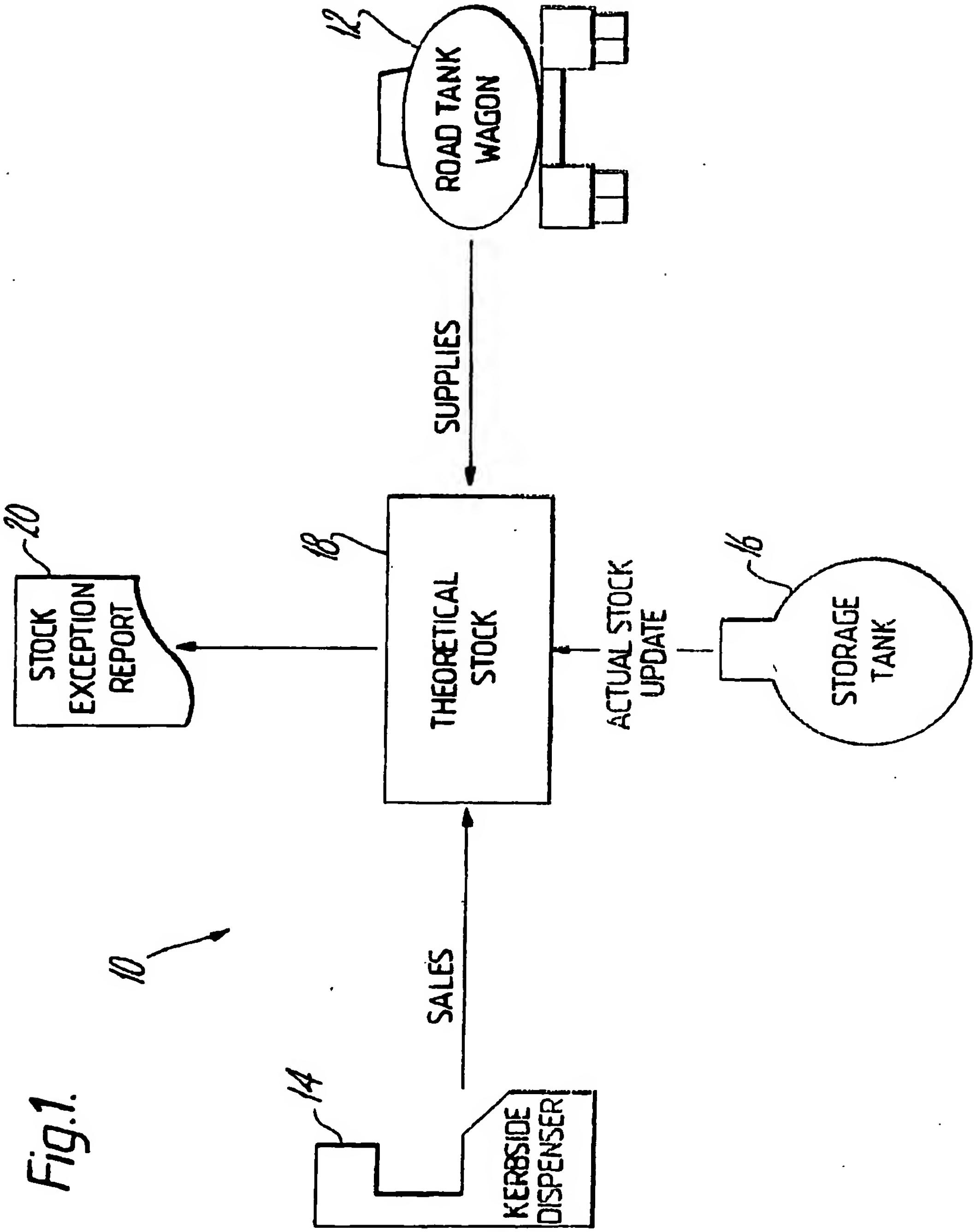

Fig.1.

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Fig.2.

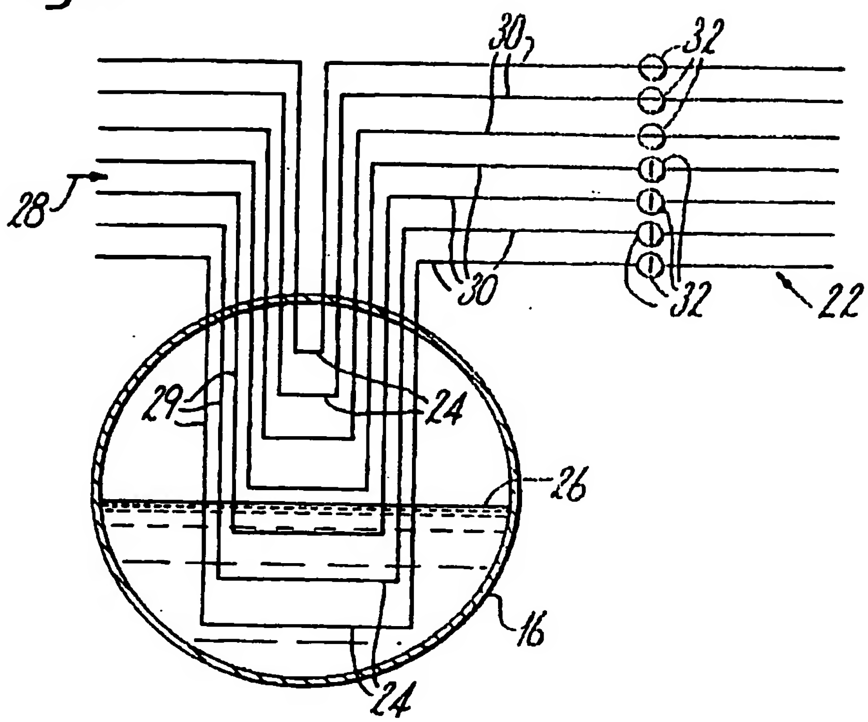
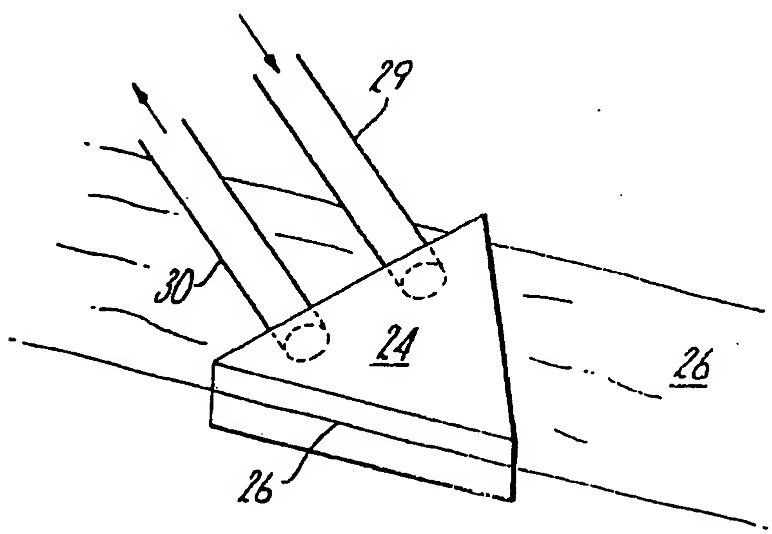


Fig.3.



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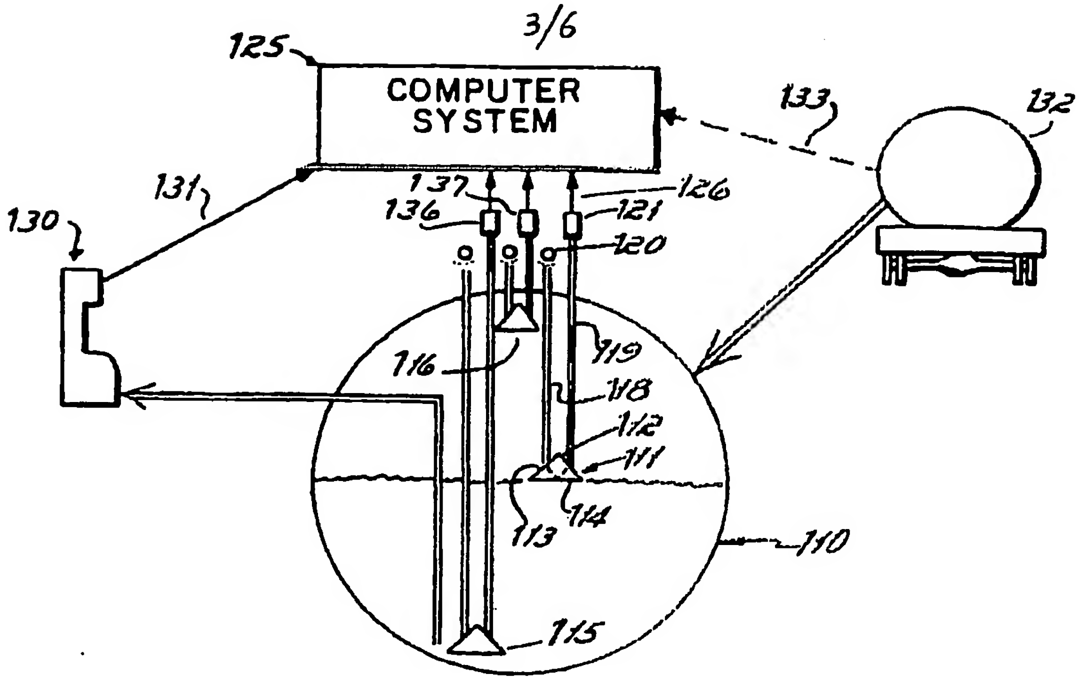

Fig.4.

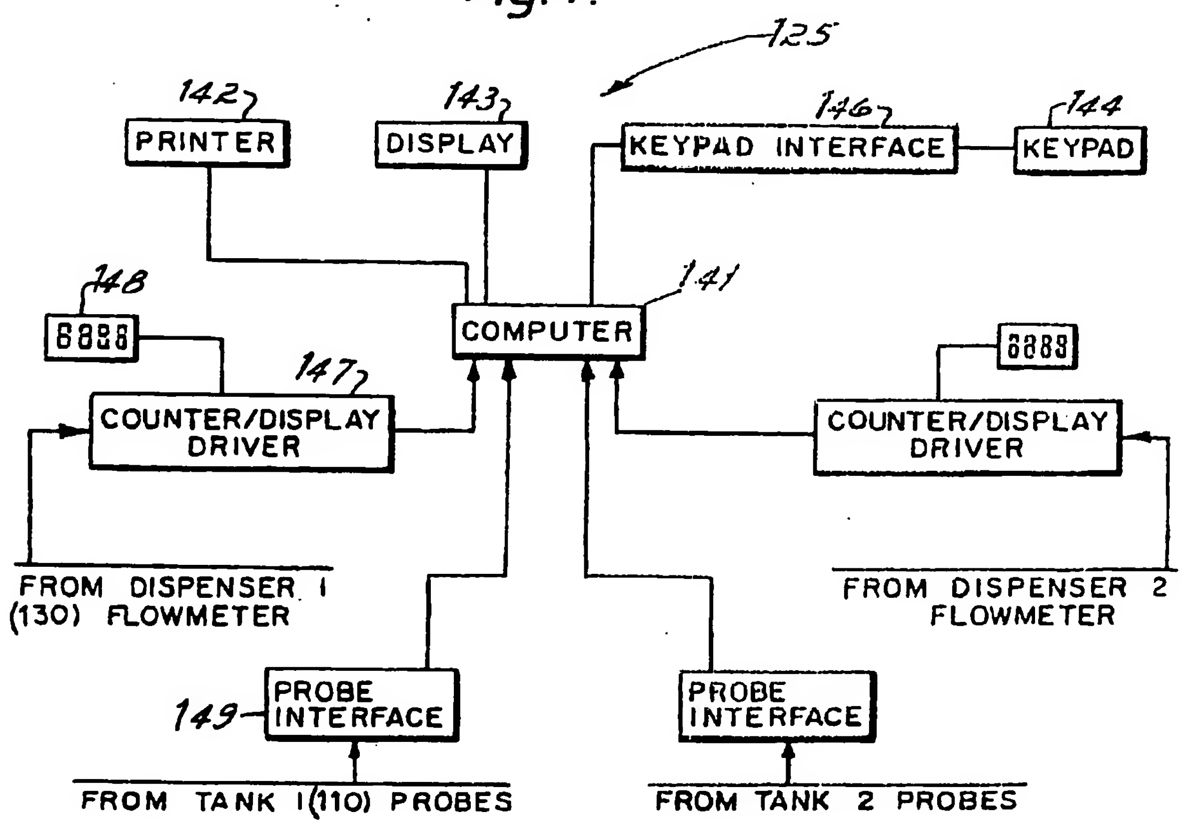

Fig.5.

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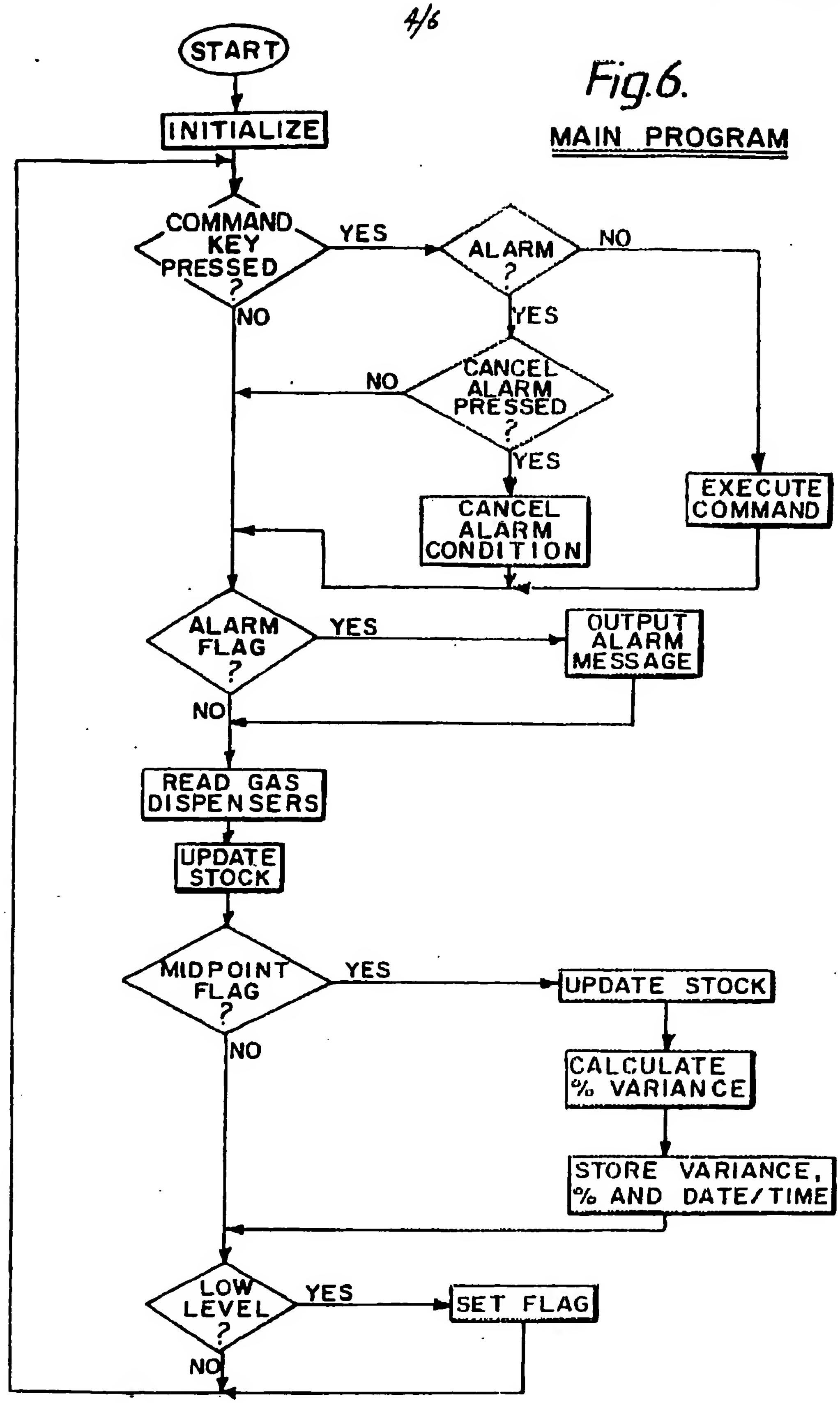
Fig.6.

MAIN PROGRAM



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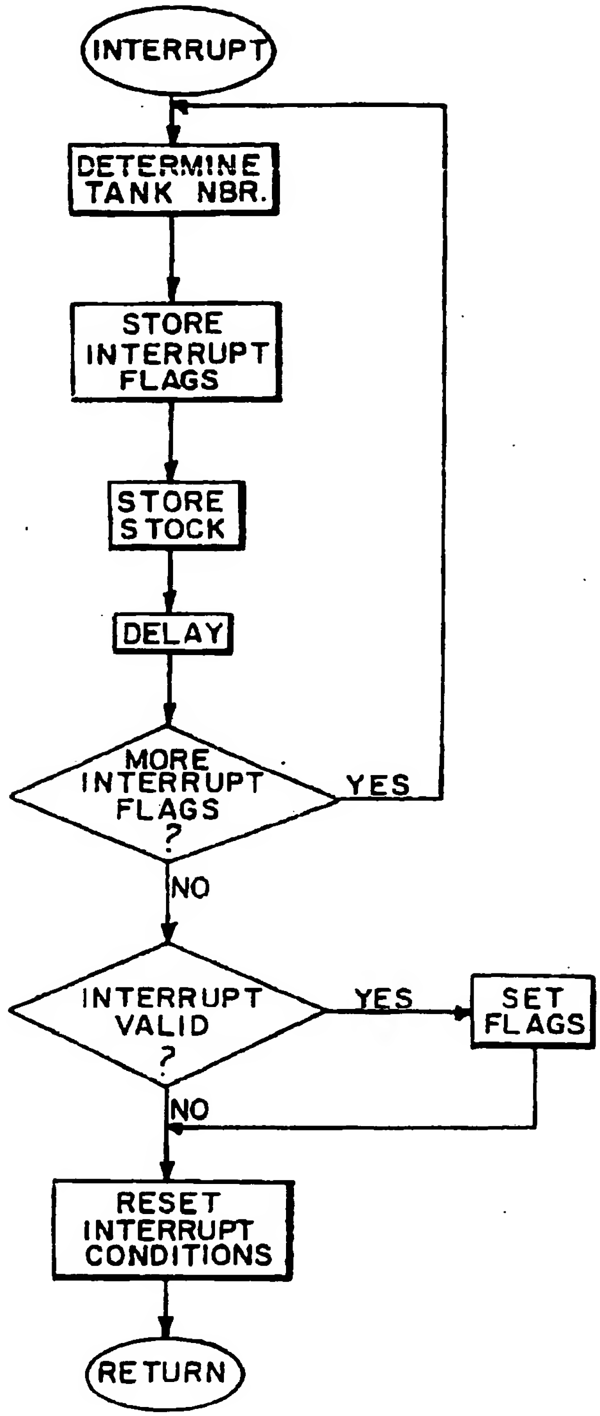
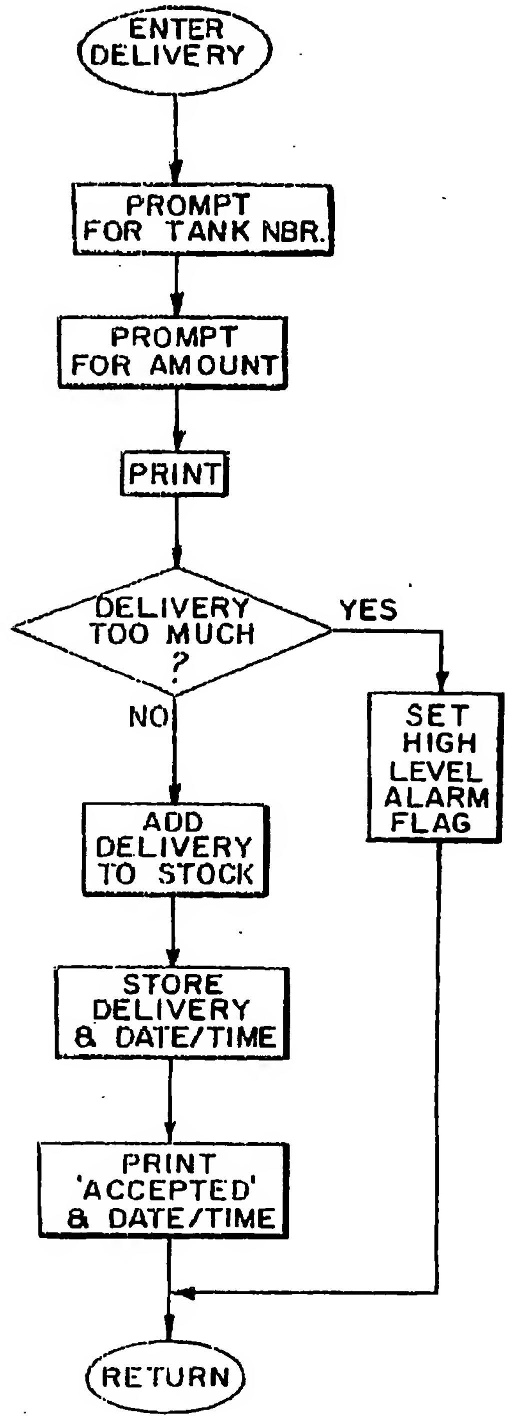


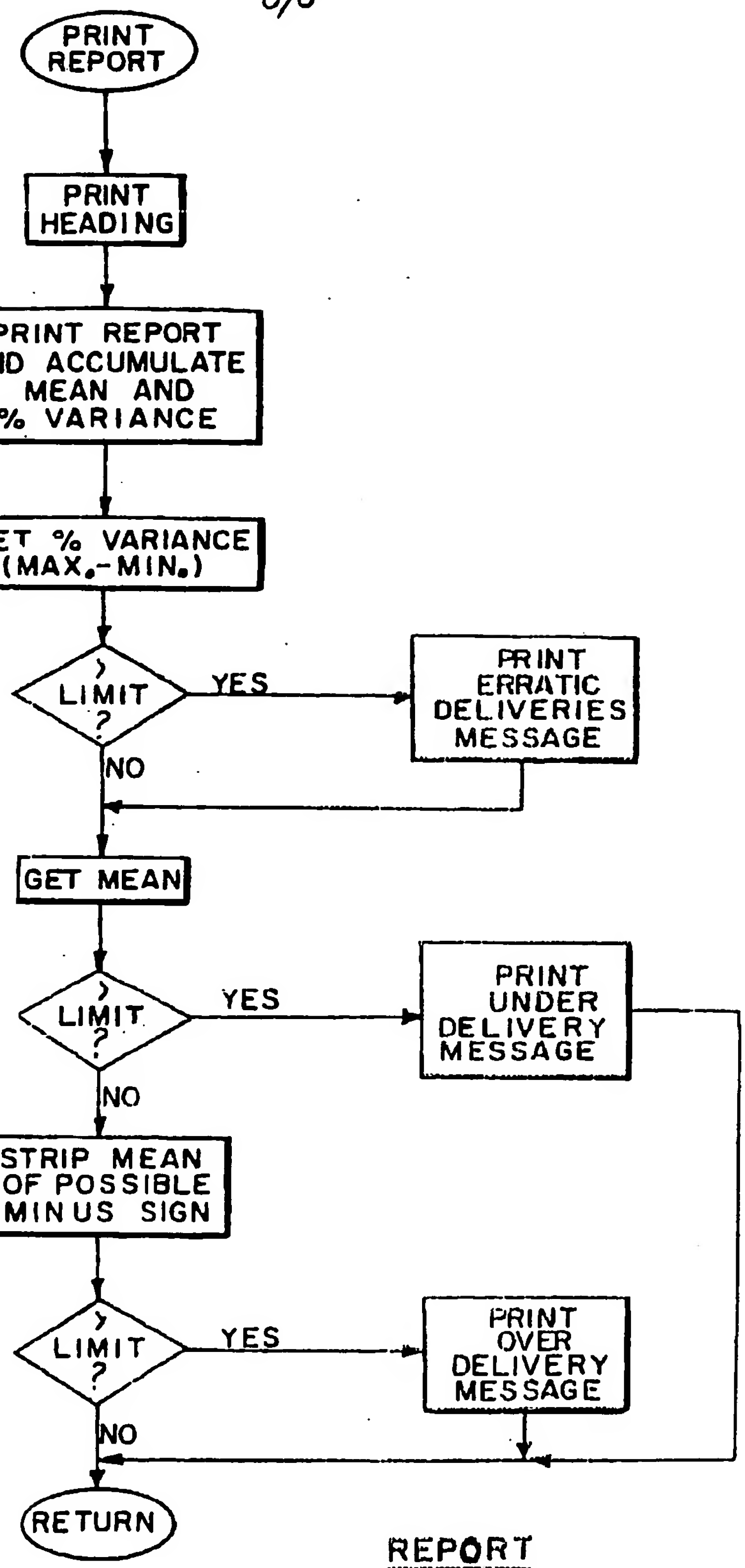
INTERRUPT ROUTINE

Fig.7.



DELIVERY

Fig.8.



PRINT REPORT
PRINT HEADING
PRINT REPORT AND ACCUMULATE MEAN AND % VARIANCE
GET % VARIANCE (MAX.-MIN.)
> LIMIT ?
YES
PRINT ERRATIC DELIVERIES MESSAGE
NO
GET MEAN
> LIMIT ?
YES
PRINT UNDER DELIVERY MESSAGE
NO
STRIP MEAN OF POSSIBLE MINUS SIGN
> LIMIT ?
YES
PRINT OVER DELIVERY MESSAGE
NO
RETURN

REPORT

Fig. 9

SPECIFICATION

Improvements in or relating to a method of control of liquid stock

The invention relates to a liquid stock control system and in particular to a control system for motor fuel kept in an underground tank e.g. at a garage forecourt.

Present garage fuel installations have the capability of giving an operator the theoretical fuel stock figure at any one time, by adding deliveries purchased and subtracting supplies made.

However, stock discrepancies often arise because the measurement of inputs and/or outputs is too error prone for reliable stock control.

In the case of garage forecourts, outputs can be measured reliably by Weights & Measures controlled delivery pumps to about an error of ± ¼%. Inputs are controlled from tanker deliveries to about an error ± 1%. It would be desirable to identify and record these errors as they arise.

To date, most systems for stock control concentrate on providing a third measurement e.g. of the quantity of fuel in a storage tank. The methods used may vary but invariably a third measurement has its own inaccuracies which may well obscure the important errors in supplies and deliveries. All known third measuring systems are reliable at best to an error of about ± ½%.

It is an object of the invention to mitigate or overcome one or more of the above problems.

In accordance with one aspect of the invention a method of control of liquid stock comprises calculating a theoretical stock level generated from input and output data, the measuring of a true stock level (preferably each time the level of stock in the tank reaches a predetermined level) and the comparison of the theoretical and true stock levels to give an indication of stock deviation.

In a garage installation application the input and output data are correlated to the total fuel brought and the total fuel sold respectively. The true stock level is measured by means of a fibre optic level detection probe in the fuel storage tank. This type of probe is in practice reliable to an insignificant error, as it is independent of variables such as specific gravity, capacitance, pressure etc.

Preferably the method includes the step of recording and/or memorizing the data and comparison thereof. A computer is preferably used to calculate and compare the data in the system. Preferably, the system will compare the "theoretical stock" generated from the inputs and outputs with the "true stock", each time the level in the tank reaches a predetermined point. The "theoretical stock" figure will be updated with the "true stock" and the deviation (plus or minus) committed to memory.

It is anticipated that the stock movement in a typical service station will give rise to approximately 20 stock updates per month.

The display of these, both individually and commulatively, will give a clear indication of loss trends. This enables further action, if necessary, to be taken based on the loss analysis. For example, if losses are continuous and relatively stable, it would indicate pump errors. If these can be eliminated and losses continue in the same pattern, a leaking tank would be suspected. If the losses were of a random nature, it would be likely that the tanker deliveries would be suspect. It would be most unlikely that consecutive deliveries would be received from the same tanker using the same compartments loaded from the same loading rack meter.

The unique advantage of the system described is that the stock deviation may be caluclated quite independently of other variables such as specific gravity, capacitance, pressure etc.

In accordance with another aspect of the invention, an apparatus for monitoring liquid stock movement to and from a storage tank comprises means for calculating the theoretical quantities of stock dispensed to and from the tank, at least one fixed level indicator mounted within the tank for accurately indicating the true stock level when the stock miniscus traverses the indicator, and means for comparing the true stock level with the calculated theoretical stock.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic diagram of a first embodiment of control system in accordance with the invention,

Figure 2 is a diagram of an example of probe for use with the system of Figure 1,

Figure 3 is a detailed diagram of part of the probe of Figure 2,

Figure 4 is a schematic diagram of a second embodiment of control system in accordance with the invention applied at a service station,

Figure 5 is a block diagram of the computer arrangement used with the system of Figure 4,

Figure 6 is an illustrative flow chart of the main program of the computer of Figure 5,

Figure 7 is an illustrative flow chart of the interrupt routine for the computer of Figure 5,

Figure 8 is an illustrative flow chart of a subroutine for entering "gasoline delivered" into the computer of Figure 5, and

Figure 9 is an illustrative flow chart of a subroutine for printing a variance report utilizing the computer of Figure 5.

Referring to Figure 1, a road tanker 12 is shown delivering liquid stock to be dispensed at a kerbside dispenser 14 for an underground fuel storage tank 16. Input data correlated to the amount of fuel delivered by the tanker 12 is fed to means 18 (e.g. a computer) together with output data correlated to the amount of fuel sold at the dispenser 14. From the input and output data, a theoretical stock calculation can be made by

the computer 18 at any moment in time.

Data correlated to the amount of true stock (ie. volume of fuel really in the tank 16) is fed to the computer 18 which then compares the theoretical stock and true stock to give an indication of stock deviation. This can be in the form of a printed stock exception report (see 20).

The measurement of the true stock is by means of a fibre optic level detection probe 22 permanently inserted in the tank 16 having at each of a number of levels in the tank 16 a fibre optic level switch 24. A fibre optic switch may be provided for upto every ¼mm in vertical height for the whole of a tank 6 usually 3 m in diameter. Alternatively, the probe may operate at only one level. Obviously each level switch 24 has to be previously calibrated for the tank in question in order to give a true stock value.

An individual level switch 24 is operated (see Figure 3) when the liquid level 26 starts to immerse the switch 24 in the form of prism. Light from a light source 28 which is usually transmitted to the prism via input means 29 e.g. a fibre optic and from the prism to output means 30, is partly stopped from reaching a photocell 32 connected to the output means 30 due to cessation of total internal reflection of the light within the partly immersed prism. This gives a true indication and value of the volume of liquid in the tank (from previous calibration) which is fed to the computer 18 at that moment in time. The computer 18 then immediately reads the input and output data from the tanker 12 and dispenser 14 and calculates the theoretical stock. The theoretical stock and true stock values are then compared by the computer 18 and the deviation committed to memory.

A typical printout obtained from a system in accordance with the invention could be as follows:-

STOCK DEVIATION ANALYSIS
ON TANKS IN GARAGE FORECOURT

	TANK 1		TANK 2		TANK 3	
	24,000 L		30,000 L		24,000 L	
	4 STAR		4 STAR		2 STAR	
DAY	LITRES	%	LITRES	%	LITRES	%
1	26	.11	70	.23	150	.62
3	+ 13	+ .05	35	.12	180	.75
5	46	.19	+ 54	+ .10	126	.53
7	53	.22	24	.08	149	.62
10	80	.33	15	.05	98	.41
13	72	.30	+ 62	+ .21	139	.58
18	24	.10	3	.01	173	.72
22	69	.29	10	.03	126	.53
25	40	.17	17	.06	187	.78
29	162	.67	+ 180	+ .60	176	.73
31	73	.30	60	.20	184	.77
AV:		.23		+.01		.64

Tank 1 and Tank 2	–	Possible split load day 29
Tank 3	–	Possible pump over-delivery.
	–	Possible leak.
Tank 2	–	Insignificant stock gain but variation indicates erratic deliveries.

As signification errors do not arise in the measurement of the volume of the fuel in the tank by the fibre optic probe, deviations between the theoretical and true stock values will represent real gains and losses from known sources.

This information can be quite useful to the operator. For example, in tank 2 there is insignificant stock gain, but the variation indicates erratic deliveries. Tank 3 shows a relatively high amount of deviation compared to the other tanks, the deviation being substantially unifom. Possibly the pump is delivering more than is transmitted to the computer, or there may be a possible leak.

In accordance with another embodiment of the invention a service station usually has at least three tanks 110, one being illustrated in Figure 4, to store the different types of gasoline such as leaded gasoline, unlead

regular, and unleaded supreme. Within each tank 110 is at least one indicator 111 which in the preferred form of the invention is a prism having two inclined faces 112 and 113 and a base 114. The base 114 is substantially horizontal, although it is preferably slightly inclined so that gasoline will flow off the surface of the base as a level in the tank is lowered.

The tank can have more than one indicator. For example, an indicator 115 is located near the bottom of the tank to provide a signal that the tank is almost empty. An indicator 116 is provided at the top of the tank to provide a warning signal during the filling of the tank that the level of the gasoline has reached the top of the tank.

Still further, a tank might have an indicator every one-fourth millimeter of vertical height to provide something approaching a continuous measurement of the volume in the tank.

Each prism has an optical fiber 118 attached to a surface 113 and an optical fiber 119 attached to the surface 112. A light source 120 is located adjacent the fiber 118 and a photocell 121 is located adjacent the fiber 119. Light rays from the source 120 are transmitted to the prism via the optical fiber 118 and are normally reflected off the base 114 to the surface 112. The optical fiber 119 returns the light rays from the surface 112 to the photocell 121. When the surface 114 becomes immersed in a liquid, the index of refraction of the liquid is so close to that of the prism that reflection no longer takes place and thus the prism acts as a switch to switch the light transmission on or off depending upon whether the prism is uncovered or immersed in liquid.

A computer arrangement 125, the function of which will subsequently be described, is connected to the photocell 121 by a line 126. Each of the prisms 115, 116 is also coupled to the computer arrangement 125 via photocells 136, 137 and illuminated by light sources through optical fibers, as in the case of the prism 111. The prism 111 is very precisely calibrated so that when the liquid level descends to the exact point of uncoveringthe base 114, the signal sent to the computer via the optical fiber 119 and the connection 126 is that of the true level or volume of gasoline in the tank.

The service station has the usual gasoline "pumps", or dispensers 130 whose information relating to the quantity of gasoline dispensed is fed to the computer by the connection 131.

Gasoline in the tank 110 is received from a tank truck 132. The tank truck has a gauge which reasonably accurately measures the quantity of gasoline dispensed during loading from the truck into the tank 110. When the tank is filled, the quantity of gasoline fed to the tank is read from the gauge and is entered into the computer, that entry being diagrammatically illustrated by the line 113.

In the operation of the system, over a period of days deliveries will be made to the tanks and liquid will be dispensed from the dispensers 130. On average, the liquid level in the tank will descent past the prism 114 several times per month. At the precise moment that the liquid passes the base 120 of the prism, the light from the source 120 is reflected to the photocell 121 producing a signal coupled to the computer, and the computer thus receives a true indication of the volume of stock in the tank at that moment. This should be accurate to within a fraction of a gallon or litre. Simultaneously, the computer reads the theoretical, or calculated, value of gasoline volume in the tank which has been determined by adding the fuel introduced and subtracting the fuel dispensed from the previous true value established the last time the gasoline descended past the prism base 114. The variance between the actual volume and the calculated volume is computed as well as that variance as a percentage of gasoline dispensed since the previous comparison. All of the computed information is stored.

At any time, the service station operator will be able to obtain a printout of that stored information, such as the last twenty entries, for example.

A preferred form of computer arrangement 125 for generating the reports and analyses includes a computer 141 (Figure 5) coupled to a printer 142, a display 143, and a key pad 144 via a key pad interface circuit 146. In the illustrated embodiment, the computer 141 is a Rockwell 65/40 single board computer (sbc). The printer 142 and the display 143 are "intelligent", each including an sbc. As shall be described, data such as gasoline delivery volumes can be entered through the key and 144 in response to prompts from the computer 141 on the display 143. The reports and analyses are produced on printer 142.

Within the practical limits of operational speed of the computer 141, various numbers of tanks and dispensers can be monitored by the computer. As indicated earlier, there may be three tanks and three dispensers, one for each of three different types of gasoline. It is also possible that more than one dispenser may be provided for a single tank. In the form of the invention illustrated in Figure 5, there are two gasoline tanks, tank No. 1 and tank No. 2, each having a single associated dispenser. Tank No. 1 may be regarded as the tank 110 of Figure 4 and the dispenser No. 1 may be regarded as the dispenser 130 of Figure 4. The dispenser No. 2 and the tank No. 2 are substantially the same as the dispenser 130 and the tank 110, with its associated level indicators. Since the tanks and dispensers are substantially the same, the operative connections for only the tank 110 and the dispenser 130 shall be described in detail.

The dispenser 130 includes a flow meter for measuring the amount of gasoline dispensed, such as into the gas tank of an automobile. The dispenser 130 typically includes a numeric display of the amount of gasoline dispensed, which is derived from the output of the flow meter. The flow meter output is also coupled to a counter/display driver 147 which drives a display 148 also showing the amount of gasoline dispensed. This display 148 is typically at the location of the computer 141, such as inside a service station for the convenience of the service station operator in monitoring the amount of gasoline dispensed at the dispenser 130. In the case of a dispenser 130 having a digital display, it is possible to utilize the electrical signals driving

the digital display at the dispenser 130 for the display driver 147, and the counter portion thereof may be omitted. As shall be described, the computer 141 cumulates the amounts of gasoline dispensed for subsequent calculations, but the display 148 is, of course, reset each time a customer dispenses gasoline from the dispenser 130.

The outputs from the probes 111, 115, and 116 in the tank 110 are also coupled to the computer 141 via a probe interface circuit 149. The probe interface circuit 149 converts the absence or presence of light at the photocells 121 into gasoline level signals usable by the computer 141. In the operation of the computer system 125, the computer 141 is responsive to the gasoline level in a tank reaching the high level sensor 116 or the gasoline level falling to the level of either the midpoint sensor 111 or the low level sensor 115. The computer 141 also, for each tank, cumulates the amounts of gasoline dispensed from the tank and the amounts of gasoline added to the tank, as input to the computer via the key pad 144.

The computer 141 operates under the control of a main program, an Interrupt routine initiated by a high or switch point level sensor signal, and a number of subroutines executed in response to operator key pad entries. With reference to Figure 6, upon power-up, the computer 141 starts the execution of the main program by initializing variables, interface conditions, and interrupts. The computer then determines if a command key in the keyboard matrix has been depressed. If not, the computer then determines if an alarm flag has been set. In the present instance, a flag is a high or low gasoline level indication from a sensor in one of the tanks. If no alarm flag is set,the computer reads the gasoline dispensers and updates the calculated gasopline stock value for each tank.

The computer then determines if a midpoint flag has been set, indicative of the gasoline level in a tank being at the switch point sensor 114. If a switch point flag is not set, the computer checks for a low level indication from one of the low level sensors 115. If there is a low level condition in one of the tanks, the appropriate low level flag is set within the computer 141. After checking for a low gasoline level, the computer then loops to the first step after initialization, that of determining if a command key has been depressed. The computer then continues to execute this loop, scanning the key pad, checking for an alarm flag, reading the dispenser counters, and checking for switch point flags set.

If an alarm flag is set, indicative of a high or low gasoline level alarm condition for a tank, this is detected by the computer in the main program loop, and the computer outputs an appropriate alarm message. This message is output on the display 143, and may be accompanied by an audible signal and a printout at the printer 142.

The low level alarm flag is set in the execution of the main program, as described above. In order to set a high level alarm flag or a switch point flag, the interrupt routine of Figure 7 is executed. This routine is initiated in response to the gasoline level in a tank reaching the level of a high level sensor 116 or falling to the level of a midpoint sensor 114.

When an inturrupt condition arises, the computer first determines at which tank or tanks any interrupts have occurred. The computer stores the interrupt flags, which have been set in response to level indicator outputs from the sensors 114, 116. The computer then stores the present stock value for each tank at which an interrupt has occurred. The computer next waits for a delay interval to assure that a true level signal has been received rather than a noise input. If during the delay interval more interrupt flags are set, the delay loop is executed again. The computer then determines if the one or more interrupt conditions are valid. For example, a high level and a switch point level indication from the same tank would be an invalid interrupt condition. For any valid interrupts, the computer sets the appropriate high level or switch point level flags and resets the interrupt conditions. The computer then returns to the main program and resumes program execution at the point at which it was interrupted.

If a high level alarm flag has been set in the interrupt routine, an appropriate output alarm message is produced as the computer executes the main program loop. If a switch point flag has been set in the interrupt routine, the computer updates the gasoline stock value for that tank to equal the known volume for the tank when the midpoint level sensor 114 is uncovered. The computer then uses the stock value stored during the interrupt routine to calculate the variance between the calculated gasoline volume and the actual gasoline volume. The variance is stored in the computer 141 together with the date and time, for subsequent inclusion in a printed variance report. The computer also stores the stock variance expressed as a percentage of the total gasoline dispensed from the tank since the last switch point condition. In the present instance, this data is stored in a circular buffer containing twenty seperate entries. A new entry over-writes the oldest entry giving a sequential historical record of the last twenty stock variances.

When a command key is pressed, the designated command is executed by the computer 141. If an alarm condition exists, the computer determines if a "cancel alarm" key has been pressed. If so, the computer cancels the alarm condition. If a high or low level alarm condition exists, the computer will only accept a "cancel alarm" command. If an alarm condition does not exist, the computer executes the selected command, which may be thought of as a subroutine, and returns to the main loop.

As illustrated in Figure 8, if an "enter delivery" command is entered at the key pad 144, the computer prompts the operator through the display 143 to enter the number of the tank to which the delivery was made. After the tank number is entered, the computer prompts for the volume of the delivery. The computer then prints the amount of the delivery and determines if the delivery amount is such that, when added to the gasoline in stock in the tank, the high level for the tank will be exceeded. If so the computer sets the high level alarm flag and returns to the main program loop.

If the delivery is not too large, the computer adds the delivery amount to the stock total for the tank. The computer then stores the amount of the delivery and the date and the time of the delivery. The computer then prints "accepted" and the date and the time via the printer 142 and returns to the main program loop.

The computer is also responsive to a "print report" command received during execution of the main program loop. As shown in Figure 9, in response to a "print report" command, the computer prints a report heading and a report of the most recent twenty stored variance data sets for each tank. This would typically include the date/time, amount of variance, and percentage of variance for each set of data.

The computer then checks the magnitudes of the percentages of variance for each tank against a preset limit. If this limit is exceeded for a tank, the computer prints an "erratic deliveries" message for that tank. The computer then determines the mean of the variances for each tank and compares the mean to a preset limit. If it exceeds this limit, the computer prints an "under delivery" message. If the mean does not exceed this limit, the computer removes a minus sign from the mean, if one is present, and compares the result to the limit once again. If the limit is now exceeded, an "over delivery" message is printed. Preferably, during report printing, a dummy read loop is executed at the end of each printed line to keep the dispenser counters updated, etc.

Other computations may be made with the data and additional analyses and messages can be included in the report. For example, a series of substantial stock variances for a tank could be analysed and identified as a possible leak in a report.

The computer 141 may also be responsive to many additional commands entered through the key pad 144. For example, in the present instance, commands are recognized for printing a list of available commands, setting the present date, setting the present time, printing and displaying the date/time, printing the volume of stock in a particular tank, printing the ullage of a tank, printing a delivery report, or producing a display of stock or ullage.

CLAIMS

1. A method of control of liquid stock comprising calculating a theoretical stock level generated from input and output data, measuring of a true stock level and comparing the theoretical and true stock levels to give an indication of stock deviation.
2. A method as claimed in Claim 1 wherein the comparison is repeated to provide data for determining trends.
3. A method as claimed in either Claim 1 or Claim 2 wherein the true stock level is measured each time the level of stock reaches a predetermined level.
4. A method as claimed in any preceding claim wherein the data and comparison thereof are recorded and/or memorized.
5. An apparatus for monitoring liquid stock movement to and from a storage tank comprising means for calculating the theoretical quantities of stock dispensed to and from the tank, at least one fixed level indicator mounted within the tank for accurately indicating the true stock level when the stock miniscus traverses the indicator, and means for comparing the true stock level with the calculated theoretical stock.
6. An apparatus as claimed in Claim 5 wherein the indicator comprises a prism disposed at a fixed position in the tank, a fiber optic system for transmitting a light beam to one face and for transmitting the light beam from another face when the third face is not covered by liquid.
7. An apparatus as claimed in Claim 6 wherein the third face of the prism is substantially horizontal but slightly inclined to horizontal so that stock flows immediately from the face as stock is emptied from the tank to a level below the face.
8. An apparatus as claimed in either Claim 6 or 7 further comprising a second prism at the upper level of the tank to signal a full condition of the tank, and a third prism at a low level of the tank to signal a substantially empty condition.
9. An apparatus as claimed in any one of Claims 5 to 8 comprising a plurality of fixed level indicators positioned at different levels in the tank in order to indicate more accurately the true stock level.
10. A method of control of liquid stock substantially as herein described with reference to the accompany drawings.
11. An apparatus for monitoring liquid stock substantially as herein described with reference to the accompanying drawings.

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